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THESIS

IMPLEMENTING MATERIAL REQUIREMENTS PLANNING
IN THE MCLB BARSTOW
DEPOT MAINTENANCE ACTIVITY

by

Cleve B. Pillifant

October 1982

Thesis Advisor: A. W. McMasters

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Implementing Material Requirements Planning in the MCLB Barstow Depot Maintenance Activity

by

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ABSTRACT

The U.S. Marine Corps will soon begin the procurement of the hardware and software required to install the DMA Integrated Management System (DIMS) in the Depot Maintenance Activities (DMA's). This system will utilize material requirements planning (MRP) as an aid in scheduling workload and determining material requirements. The objective of this thesis was to develop an implementation strategy for installing the proposed DIMS in DMA Barstow. The first phase of the development consisted of a extensive literature review regarding the development and implementation of MRP systems in the private sector. The differences between the MRP environment in the civilian manufacturing firm and the depot overhaul facility were then analyzed. Next, an analysis of DMA Barstow's readiness to begin preparing for implementation was conducted. Finally, an implementation plan is proposed which incorporates both DMA readiness and those unique aspects of a military repair facility which distinguish it from a private sector manufacturing activity.

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I. INTRODUCTION

Material Requirements Planning (MRP) is not a new concept in the inventory and production control environment, it has been used quite successfully in many large manufacturing corporations since the early 1960's. The popularity that MRP currently enjoys is a by-product of the recent explosive advances in computer technology. These advances have resulted in greatly reduced hardware prices and placed an affordable, compact and more powerful machine in the hands of many smaller users. MRP success stories fill the pages of many professional periodicals. Vendor salesmen expound on the virtues of MRP and make grand promises of how their hardware and MRP packages can solve all or many of a company's manufacturing problems. Hidden among these powerful stories of stunning successes are the warning voices of those failures which must be heeded and considered before plunging head-long into implementation of an MRP system. Reports are now appearing in some periodicals concerning the apparent failure of installed MRP systems to meet their potential. These reports point out that the company may be realizing some benefits from MRP but that the potential of the system is much greater than what is being utilized. The literature suggests that what separates a successful MRP system from one that is " working " is the company's degree of thoughtful preparation for the implementation of the system.

While MRP works quite well in the manufacturing environment, its performance in a rebuild/overhaul environment such as the type encountered in a military depot level maintenance activity is largely untested. This thesis

examines the standard manufacturing MRP system and highlights the differences between the manufacturing and the rebuild environments and its implications for software design. In addition, an implementation plan is proposed for the Depot Integrated Management System (DIMS) that will soon be procured for use in the U. S. Marine Corps Depot Maintenance Activity in Barstow, California.

II. BACKGROUND

A. DEPOT MAINTENANCE ACTIVITY BARSTOW

1. Mission

The Repair Division is one of five operational divisions onboard the Marine Corps Logistics Base (MCLB) at Barstow, California as depicted in Figure 2.1.

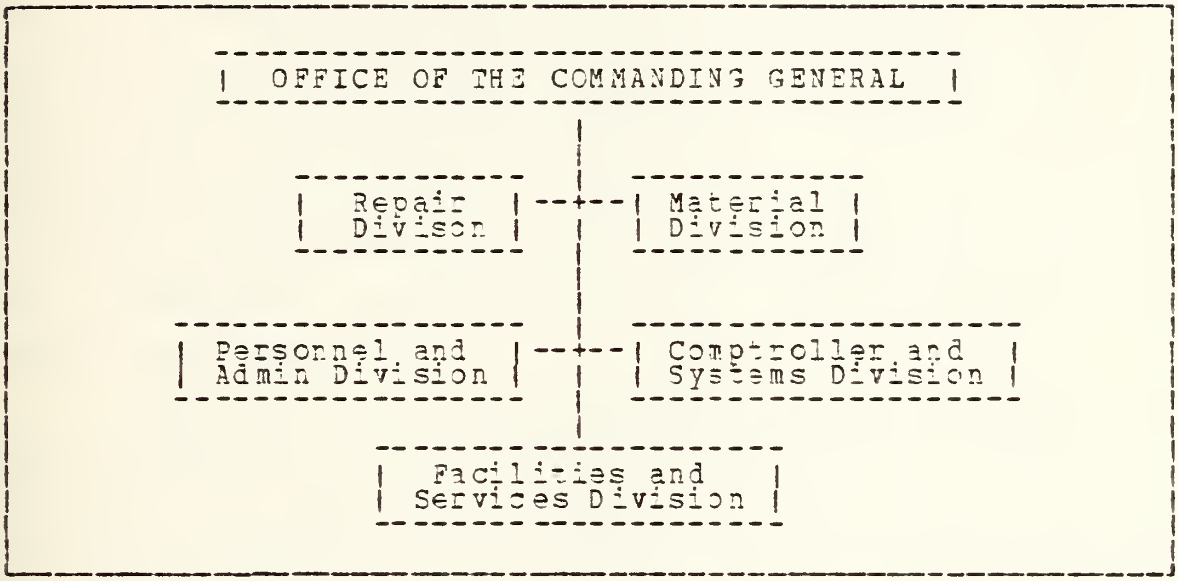

Figure 2.1 MCLB Barstow Organization Chart

When it was designated an Industrial Activity in 1968, the MCLB Barstow Repair Division joined the Repair Division at MCLB Albany, Georgia as the only industrial funded Depot Maintenance Activities (DMA's) in the Marine Corps. Staffed by 720 civilian employees and 187 Marines, the DMA's are responsible for the overhaul, rebuild, repair and modification of all ground equipment in the Marine

Corps' inventory. In a typical fiscal year the DMA will process 8,000 to 10,000 end items under more than 500 different work requests. The diversity of this equipment is quite impressive. Ordnance items range from the M1911A1 .45 caliber pistol to the self-propelled 8" howitzer. Electronics items range from simple power cable repair to a sophisticated overhaul of the improved HAWK missile system radars. Add to these examples numerous wheeled and tracked vehicles and there is a staggering array of Marine Corps equipment processed through the DMA.

DMA Barstow also has a mission to provide depot-level calibration services through its Calibration Branch which is a designated Calibration Laboratory (Cal Lab) in the DoD calibration system. The Cal Lab is tasked with the repair and calibration of electronics, radio and various mechanical test equipment. These services are not limited to Marine Corps activities alone but include many interservice commitments negotiated through several interservice support agreements.

In addition to its maintenance responsibilities, the DMA is tasked to provide technical assistance and inspection services for Fleet Marine Force and Marine Corps Reserve Units in the western United States. In this regard, the DMA provides several inspection and assistance teams that visit each reserve unit annually providing whatever services are required.

The DMA in Barstow is currently being considered for establishment of a West Coast Tracked Vehicle Repair Center. If this additional responsibility is placed on the DMA it will significantly increase the quantity of items processed while increasing slightly the broad range of items already processed by that facility.

A majority of the DMA workload is programmed by elements of Headquarters Marine Corps (HQMC) whose responsibility includes the projection of Marine Corps overhaul requirements. The assignment of Secondary Depot Reparables (SDR) items for rebuild and repair is made by the Inventory Control Point (ICP) located at the Marine Corps Logistics Base, Albany, Georgia. While these two sources account for most of the work done by the DMA, workload also comes from various interservice support agreements and competitive bidding on DoD work.

2. Organization and Structure

The DMA consists of seven branches, two of which are operational while the remainder provide supporting administrative and control services. Figure 2.2 depicts the DMA organization structure and Figure 2.3 reflects the division of Shops Branch into task oriented subunits called Control Centers. These Control Centers are further organized into 27 Cost Work Centers (CWC's) which actually contain the personnel who perform the maintenance functions alluded to in the previous section. The CWC's are organized on the shop floor in the usual job-shop configuration. Segregated by activities, the personnel and plant equipment are stationary while the item to be rebuilt is brought to the CWC. The rebuild operations are performed in the CWC and the equipment is then moved to the next CWC in the rebuild sequence. The CWC is the basic element in DMA management and control of job performance, time and attendance, fiscal responsibility, and proper execution of its part in the rebuild schedule.

Most of the DMA is housed in building 573 which encompasses almost ten acres under one roof. This enormous building contains all branches with the exception of the

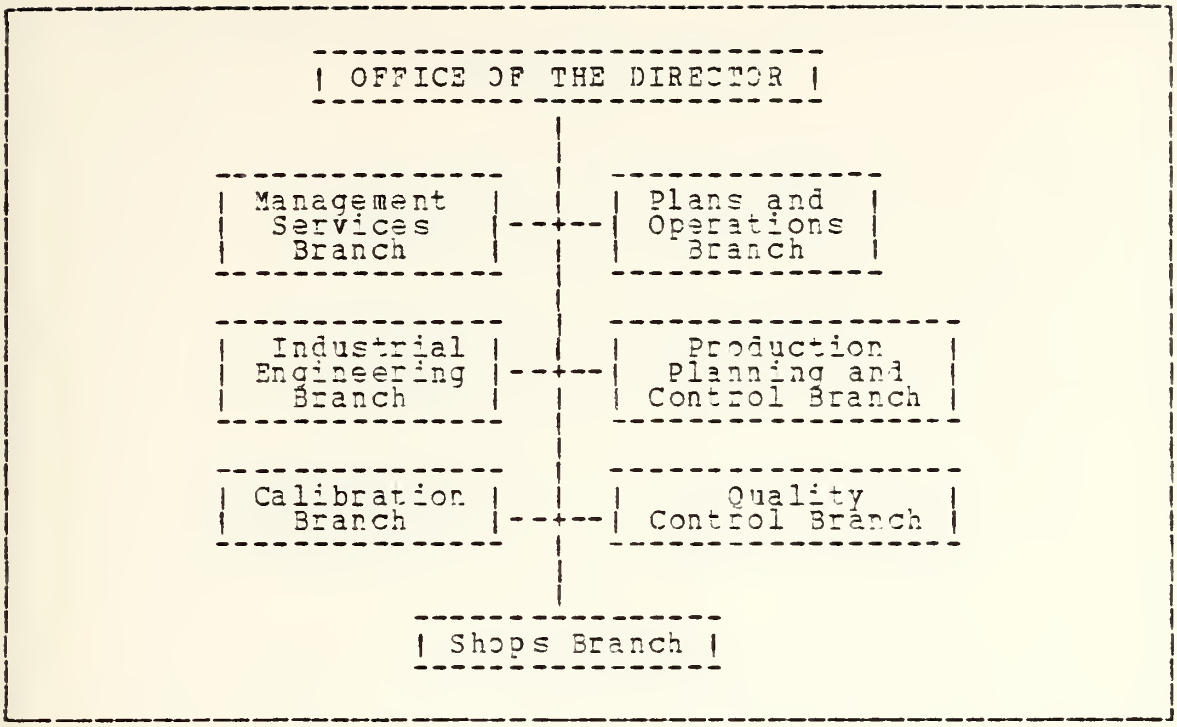

Figure 2.2 DMA Barstow Organization Chart

Calibration Branch which is located in a separate facility a quarter of a mile away. Building 573 is surrounded by a paved surface upon which incoming equipment and completed items are stored pending induction or shipment. Warehouse 405, which contains repaired and new parts for use by the DMA, is located one-half mile from 573 and is staffed by personnel from the Material Control Section of the Production Planning and Control Branch. A small portion of Shops Branch is located in building 203 just off the paved surface surrounding 573. This section performs preparation-for-shipment and most care-in-store work for the DMA.

The remaining five branches provide the support required by the Shops and Calibration Branches in the performance of their duties. These branches make up the overhead portion of the DMA and are task organized with

```
                    -----------------
                    | Shops Branch  |
                    -----------------
                            |
                            |
        -----------         |     -----------
        | Vehicle |---+---| Weapons  |
        |  Shop   |   |   |  Shop    |
        -----------         |     -----------
                            |
                            |
        -----------         |     -----------
        | HAWK &  |---+---| Support  |
        |  Radar  |   |   |  Shop    |
        -----------         |     -----------
                            |
                            |
  -------------------       |     ----------------
  | Communications  |---+---| Prep For Ship  |
  | & Electronics   |   |   | Care-In-Store  |
  -------------------       |     ----------------
                            |
                            |
                  -----------------
                  | Clean, Paint, |
                  |   and Lube    |
                  -----------------
```

Figure 2.3 Shops Branch Organization Chart

duties comensurate with their titles. These branches are largely consolidated in a single worksite with the exception of the Production Planning and Control (PP&C) and the Quality Control (QC) Branches. PP&C and QC personnel are distributed throughout the physical workspaces (shop floor) of the Shops and Calibration Branches. PP&C is represented on the shop floor by two different types of employees; job shop planners and material expediters. The former are generally co-located with the CWC foremen and have some technical background with the commodity on which the CWC is working. Their job is to assist in the actual execution of the master schedule once the job is in production and to serve as a vital link between the CWC and the production controllers who schedule the workload and monitor job

progress. Among other duties, the shop planners record production counts , identify and resolve all manner of problems relative to an active job and play a vital job management role in tandum with the CWC foreman. The material expediter is also located in the CWC area on the shop floor. This individual is responsible for the daily logistics support of the CWC. The expediter initiates the issue of required materials, routes outgoing components/ parts, records incoming routed material, processes requisitions for new parts/materials and receives and stores all incoming material to the CWC. QC personnel are located in various areas of the shop floor to inspect work procedures, test quality, ensure proper configuration of the end item and record the necessary acceptance of the end item for final acceptance.

3. Current Data Systems Support

The DMA receives its data processing support from the Automated Services Center (ASC) located approximately 12 miles from the DMA on the mainside portion of MCLB Barstow in Nebo. The DMA's management system consists of a single Class I system referred to as the Depot Maintenance Subsystem (DMSS) which was developed in the 1960's. The system's files are updated on a daily basis using a batch process on an IBM 360/50. While certain processing changes have occurred since DMSS was introduced, the management reports remain largely the same.

There are three SCANDATA source data automation (SDA) devices located in the DMA which were planned to replace the keypunch machines used to prepare data to update the DMSS files. However, keypunch cards remain the most significant means used by the DMA to update these files due to the small number of SDA devices available and the time

saved with only a few DMA personnel involved with the data entry preparation.

In addition to keypunch and SCANDATA, the DMA has recently installed an ESSEX time and attendance system. This system records all employee time charges for payroll and job accounting purposes. These time charges are recorded on floppy disk and the DMSS and payroll systems are updated daily by means of a modem located with the ESSEX CPU located in the DMA.

Other than the above devices, the DMA possesses no internal data processing equipment and relies on output from the DMSS for all production and material management. Unfortunately, this output does not include many reports that are required to properly manage the DMA's production and materials. These shortfalls have been recognized by DMA personnel over the years and a complicated labyrinth of supplemental Class III (locally designed and controlled) programs and MARK IV information retrievals have been added to the normal DMSS process to provide the management reports required to properly guide DMA managers in their decision making. Suggested changes to the DMSS have been proposed to incorporate these reports as a part of the standard output yet DMSS remains largely the same, unchanged by these innovative suggestions. The current DMSS does not address the following areas of concern to DMA management.

a. Inventory Control

Widely used methods to manage on-hand material such as ABC analysis or stagnant inventory reports are not included in DMSS. Inventory procedures are not included making cyclic or physical inventories strictly a manual process and any adjustments must be made in a tedious sequential process that is time-consuming and prone to

error. The DMSS does not retain data for leadtime calculations nor does it collect and maintain records of actual material usage.

b. Bill of Material

The DMSS does not include a Bill of Material (BOM) file. Those items managed by the Marine Corps ICP (MPB) can be reserved for use by the DMA using a procedure referred to as "building a BOM". This procedure is used to identify ICP material required for a specific job to be worked in the DMA and request that a quantity "x" be reserved in anticipation of that requirement. The items loaded to the BOM file at the ICP remain on file in DMSS until the job is complete. When the job is closed out in the DMA, all material records are deleted and no history of parts used is retained on file.

c. Shop Floor Control

All routing is accomplished on a manually prepared routing tag. Once an item enters the repair cycle, the only record of that item is that maintained by the originator and only consists of the start stub and the process stubs sent back to the originator when a repair process is completed. There is no central data base to query for routing status nor are there any exception reports generated to identify late or missing items in the system. There is no adequate method for identifying items that require expediting once they are in the system other than to physically track them down and so inform the CWC's holding them. This method can quickly drain manpower when, on any given day, there are usually over 10,000 routed items on the shop floor.

d. Production Management

All CWC workloading is done by manual means as is all scheduling. Past performance on a job is filed in a folder and not readily accessible to production controllers for current performance comparisons. The impact of proposed changes in workload or DMA resources cannot be anticipated other than by the "best guess" of experienced personnel.

4. DMA Supply Support

Table I was derived from an analysis of a random sample of requisitions to determine the primary DMA sources

TABLE I

DMA Supply Source Analysis

Source of Supply	*Percentage
Defense Logistics Supply Agency (DESC, DCSC, DGSC, DISC, etc)	65%
Army Material Readiness Command (TARCOM, MICOM, ARMCOM, etc)	15%
Marine Corps ICP (MPB)	14%
Other (GSA, Navy, Air Force)	6%

*Percentage based on an analysis of 2,500 documents exclusive of Local Procurement or Mini-BOM items.

of supply. This analysis included only those items which were requisitioned by the DMA and was based on the number of requisitions submitted and not their dollar value.

The source of supply is of course dependent upon the product being processed in the DMA. Many of the electronic parts are managed by DESC, which is a component of DLA, while tracked and motor vehicles fall under the management responsibility of the Army. The recent trend is for management of consumable parts now managed by the services

to be transferred to DLA. This will mean an even greater role for DLA in the supply support of Marine Corps DMA's in the future.

Perhaps the most significant information contained in table I is that the DMA receives such a small portion of its supply support from the internal logistics support system. The DMA is, for all practical purposes, totally dependent upon sources external to the Marine Corps for its supplies.

The DMA receives its materials through the use of funded requisitions to the source of supply. Figure 2.4 depicts the DMA's requisition and material flow to the three sources of supply support; local procurement, Direct Support Stock Control (DSSC) Mini-BOM, and the Integrated Material Manager (IMM). Local procurement is primarily limited to chemicals used in the stripping and degreasing process, sand blast materials, bulk quantities of steel, and other items as needed to support DMA operations. The DMA obtains approximately 90% of its material support using funded requisitions to the source of supply.

These requisitions are generally submitted at the time the job is inducted for rebuild because funds for the job are not received until then. While most lead-imes for the DMA are not excessive as evidenced by table II, this method of ordering leaves the DMA extremely sensitive to leadtime variability.

In order to relieve this situation, a method of obtaining some materials well in advance of the planned induction date has been established. The DMA's corpus of $2.5 million will not permit the DMA to submit funded requisitions for many parts in anticipation of workload. Therefore, the Direct Support Stock Control Activity (DSSC) is utilized to obtain some materials identified for the DMA

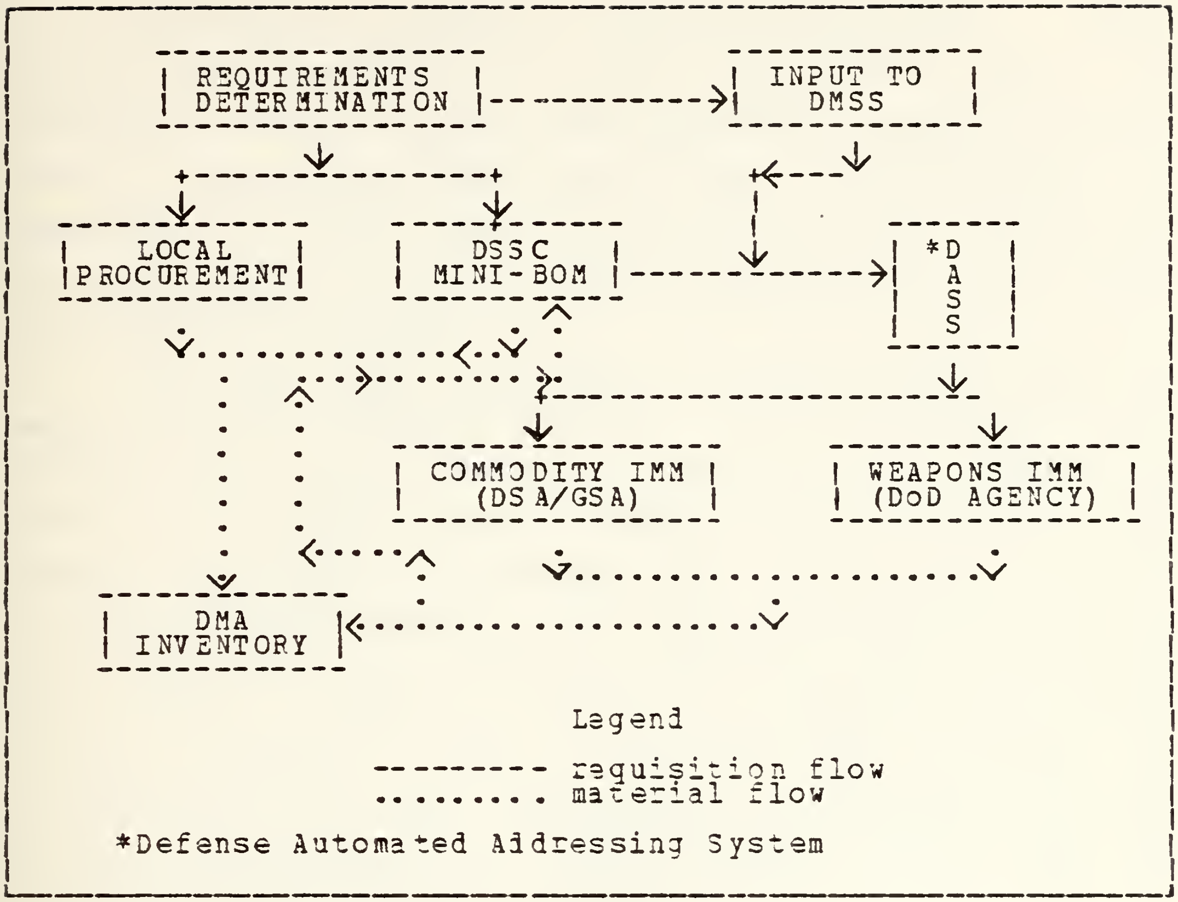

Figure 2.4 DMA Requisition/Material Flow

TABLE II

DMA Leadtime Distribution

Leadtime (Days)	DMA Overall	# of receipts MPB	DLA	ARMY	OTHER
0-15	44%	111	802	163	18
16-30	33%	91	591	88	63
31-45	7%	47	57	49	18
46-60	3%	19	35	10	11
61-90	6%	42	74	23	10
90-120	3%	12	34	15	6
121-180	3%	21	24	23	2
180 +	1%	14	4	13	4

using the stock fund instead of the DMA's industrial funds via a "Mini-BOM" procedure recently established. These materials must be parts that have a high dollar value, long leadtime or are high usage items for which the DMA can guarantee a sale to the DSSC stock fund. This material is identified by the DMA prior to the start of the fiscal year and DSSC obtains it to meet the quarterly requirements established by the DMA.

Not all parts for use by the DMA can be obtained using the DSSC Mini-BOM system. DSSC is restricted to ordering only those items not managed by the Marine Corps since the DMA can readily reserve Marine Corps managed stocks using existing procedures with the Marine Corps ICP. A funding ceiling prevents DSSC from stocking all DMA parts and is currently authorized to expend only $3.1 million for this purpose. DSSC is seeking to increase its funding ceiling in order to carry a broader range and depth of materials for the DMA. What cannot be procured using the Mini-BOM process must be requisitionedp by the DMA and funded using its industrial funds.

The MILSTRAP system, used by all IMM's in the DoD supply system, provides another method for the DMA to reserve material based on forecasted need. The Special Program Requirement (SPR) request is used to inform the responsible IMM of future requirements. After receipt of the SPR, the IMM examines the size of the requirement to determine its acceptability in terms of the risk of long supply being generated in the event of cancellation before its support date by the requester. In accomplishing this measurement, consideration involves the size of the forecasted quantity in relation to the items normal demand estimation, the cost of the quantity, the items current supply status, funding capability of the IMM, accuracy of the

submitter's past forecasts, and the degree of assurance that requisitions will follow. The IMM will determine the action to be taken on SPR requests and inform the submitter of acceptance or rejection within 15 calander days [Ref. 1].

Recently, representatives from the military services and DLA met to review the SPR program [Ref. 2]. One of the areas discussed was the parameters used by DLA for acceptance of SPR's from the military services. DLA announced the following policy improvements that should result in increased SPR acceptance:

a. The maximum acceptance quantity (MAQ) was increased from one month to two months of DLA demand.

b. The number of project codes that allow SPR's to be automatically accepted are being expanded.

c. A separate MAQ factor is being programmed to allow separate factors for high, medium and low value items by service, Defense Supply Center or Federal Supply Class.

Table III is an analysis of SPR's submitted to DLA during FY 81 [Ref. 2]. As can be seen, the Marine Corps has made little use of the SPR program in relation to the other military services. The Army and the Navy's use is primarily in the support of their depot level maintenance programs. The DMA's limited use of the SPR program in the past is believed to have been caused by an inability to forecast material requirements over the one procurement leadtime horizon required in the SPR process.

5. Planned Procurement of a Mini-Computer System

Recognizing that the above deficiencies exist and hearing of the publicized successes of private companies using MRP, the DMA began to investigate the use of MRP in

TABLE III

SPR FY 81 Statistics

Service	SPR's Received Number	SPR's Received Value*	SPR's Supported Number	(%)	SPR's Supported Value*	(%)
Army	244,700	$28,298	231,403	(95)	$10,263	(36)
Air Force	8,503	11,765	8,175	(96)	6,946	(59)
Navy	158,209	37,815	154,879	(98)	27,012	(71)
Marine Corps	51	175	30	(59)	50	(29)
Total	411,463	$78,053	394,487	(96)	$44,271	(57)

* in thousands

late 1979. This prompted a re-examination of existing data processing support and the survey of more modern approaches to production and inventory control made possible by MRP and the technological state-of-the-art of the computer industry. This study resulted in a proposal to the Commandant of the Marine Corps (CMC) to utilize this technology in the DMA. The Marine Corps' mid-range ADP plan calls for the eventual removal of the IBM 360 system at MCLB Barstow and the processing of existing systems via teleprocessing and remote job entry. This decision prompted the DMA to consider running the MRP system on a mini-computer system procured for that purpose. This concept was approved by CMC in January 1981 and the DMA was tasked with submitting a functional description of the proposed system. That document was completed in May 1981 and provided for an MRP system using a number of interactive terminals and bar code readers to input data into the system. The functional description was approved by CMC in September 1981 and the DMA was then tasked to prepare detailed system specifications for the proposed system. This task has recently been completed and

CMC is about to enter the procurement phase of the project to obtain the necessary computer hardware and software required to begin implementation of the proposed system.

The system is planned to consist of four subsystems; inventory control, shop floor control, material requirements planning, and production control. The latter will include capacity planning and routing control. Future expansion of the system is planned to include addition of the following; Quality Control, Industrial Engineering, Financial Management and the automation of several local administrative functions such as health monitoring and the benefical suggestion program.

B. MATERIAL REQUIREMENTS PLANNING

The purpose of this thesis is not to describe the MRP process in detail. However, the reader must have a basic understanding of how MRP works in order to understand its impact on an organization. What follows in this section is an overview of the fundamentals of MRP. The reader will find a number of sources in the list of references at the end of the thesis which explore MRP in greater depth.

1. Objectives of MRP

The basic objective of MRP is to accurately forecast material requirements over a certain demand period. Once accomplished, timely purchasing action can then be taken to ensure that material is on hand when required. While this concept is simple to understand, when a large number of items are involved the task becomes significantly more complex and difficult. Since the mini-computer explosion of the 1970's, the mechanization of this process has brought MRP within the grasp of even the smallest firm. MRP offers benefits not possible with a manually run system. The

promises of lower inventory levels, reduced material shortages, less time spent expediting, increased productivity and product quality have become MRP's rallying cry. These benefits are made possible because a production activity can now use the power of computers to effectively plan ahead using MRP. Many attractive modules are also available and make use of the MRP database to accomplish other important tasks such as shop floor control, capacity requirements planning, product accounting and engineering control.

2. Prerequisites and Assumptions of MRP

In his book on MRP, Joseph Orlicky sets forth several prerequisites and assumptions upon which MRP systems are based [Ref. 3: pp. 38-41].

a. Existence of a master production schedule that can be stated in terms of a bill of material. The master schedule is the basis for all planning in the manufacturing organization. It must be an accurate plan of production requirements as it is used to plan for all resources needed. MRP uses the master schedule to identify what products are required and when they must be completed. These products must be identified in an unambiguous manner in order for the correct bill of material to be accessed for the parts explosion. This requires that the product configuration be known and identified with its own unique number.

b. Existence of a bill of material for each uniquely identified product is required before material planning can take place. The BOM is a list of the components, subassemblies and piece parts that make up the product and a description of the way they are assembled. The BOM must represent the way a product is manufactured rather than its design so MRP can explode the product on the master schedule into its gross requirements. Each of these

components, subassemblies and piece parts must be identified with its own unique part number as well. These will be the numbers used by MRP when the material requirements are being computed.

c. There must be inventory records available for the MRP system to access during the determination of the parts required to meet the schedule. These records must contain not only inventory position data but the inventory control data as well. In addition, MRP presupposes that all materials used in the production process physically flow through the organization's inventory system records.

d. MRP must be operated in an environment of file data accuracy that is strictly adhered to by all members of the organization. Of course, MRP could be operated with erroneous data but the resulting output would not be of much value and the system would not be successful.

e. MRP assumes that there is discrete disbursement and usage of materials. Items that are used in continuous form (rolls of sheet metal or coils of wire) require modification of the standard MRP system.

f. All components of an assembly must be available at the time an order for that assembly is released. The basic assumptions are that the assembly process is short and the components are consumed simultaneously.

g. Process independence of manufactured items is assumed. This means that a manufacturing order for any item can be started and completed on its own and not be dependent on another order in the process.

3. Inputs to MRP

MRP requires the existence and maintenance of three files to provide the prerequisites as discussed above and explained in the following paragraphs.

a. Master Schedule File

This file contains the scheduled output of the organization that is essential to the process of time-phasing the material ordering and issue to the shop floor.

b. Bill of Material File

This file contains the level-by-level breakdown of the products included in the master schedule file. It identifies the various components, subassemblies and piece parts used in the product's construction, the sequence in which they are assembled to make the final product, and identifies the quantity used in each application. It is this file that provides the information necessary to create a "parts explosion" of the end item in the master schedule.

c. Inventory Record File

This file maintains the inventory position of each part used by the organization. A record of the on hand balance, allocations to a specific job, and quantity and status of all parts due in are included in this file. Inventory control data is also resident and includes such things as; location of on hand stock, order policy, inventory frequency, shelf life, special handling instructions, leadtime, source of supply, unit of issue, unit price and part description.

4. MRP System Processing

The master schedule is the basis for MRP, it is from this plan of production that the material requirements are computed. The system does this by using the BOM file to compute the gross material requirements for each job. The net material requirements are then computed by subtracting those assets which are on hand or on order and not

identified to a specific job. These assets are allocated to the job at this time. The requirements are then time phased to meet the completion dates contained in the master schedule. Ordering of the net requirements comes next and depends on the item leadtime and its order policy. This process is actually no more than a mechanized method of answering four questions. What are we going to do? What will we need to do it? What do we already have? What do we need to obtain? MRP is a method of achieving the age-old goal of all logisticians; the right material to the right customer in the right quantity at the right time in the right condition.

5. Output of MRP

Output from the MRP system is more a matter of human creativity than of system limitation. A multitude of user defined reports can be generated using the considerable information contained in the files that comprise the MRP system. Exception reports, performance reports, inventory level projections, purchase level projections, where used reports and product structure are just a sample of the type of reporting possible in the MRP environment. Because the possibilities are enormous, the user/manager could find himself swamped with output. The challange is to make the reports concise and comprehensible to the receiver. One of the frequent criticisms of MRP is that it really means "More Reams of Paper". But this is a controllable factor and the reports generated by the system should be given thoughtful consideration to facilitate their usefulness throughout the organization.

6. Closing the Loop with MRP II

MRP II is a newly coined term that is an extension of the basic principles of the standard MRP system. Also referred to as "Manufacturing Resource Planning", MRP II is not just concerned with the material requirements in the production process but with all resources consumed in the manufacture of a product. The following capabilities, when added to the MRP system already discussed, provide for a concept of total resource planning.

a. Capacity Planning

The master schedule must be a realistic plan of production for MRP to be successful. It cannot be what the organization would like to make, it must be what the organization is capable of making. MRP would be of little value if the master schedule were an unreasonable plan which is not supported by plant capacity. Consequently, it is necessary to mold the prioritized list of desired production to plant capacity.

When developing the BOM it is necessary to determine the work required in order to determine the materials needed to accomplish that work. This process can then lead to the development of an established sequence in which the product is processed through the plant. This sequence can be matched with the work center that performs the task and the result is a routing plan for each item that can be loaded to a routing file. By matching the standard hours allowed with each task, a workload for each work center can be computed.

Capacity planning accumulates the standard hours assigned the work center based on the master schedule and the product routing and compares this to the hours available in each work center. The resulting overloads and underloads

can then be identified and the schedule adjusted or additional resources obtained to make the schedule fit the organization's abilities to produce. It is in this manner that work center workload can be balanced and the master schedule be given validity.

Many software modules are available that accomplish the above and provide the capability of simulation in addition. This "what if" simulation allows the production controller to observe the effects of schedule changes on the organization. Informed decisions can then be made regarding the change and its impact on the organization. This type of planning helps to stabilize the environment in which MRP and the organization are operating.

b. Shop Floor Control

Monitoring the execution of the production plan is the beginning of the feedback that creates a "closed loop" system. Sometimes referred to as input/output control, this addition provides the ability to track the product throughout the production process. This module is usually tied in with the organization's time and attendance system to collect the hours worked on specific jobs and the production operations performed on a particular job. Utilizing this information and the routing data developed above produces a wealth of reports that assist users at all levels to monitor job progress. Job tracking, automatic routing, direct hour performance, daily prioritized work lists for work center foremen, expediting and, perhaps more importantly, unexpediting are all possible.

c. Inventory Control

Integral to the MRP system is a method of controlling an organizations inventory. When inventory control

is interfaced with the shop floor control module, it is possible to have materials on hand and allocated to the job automatically released to the appropriate work center at predetermined times in the production schedule. Feedback in the form of shortage reports provide management with advance information of likely future material shortages threatening the schedule. Issues, receipts and inventory adjustments are recorded as they occur and the inventory database is updated accordingly.

d. Financial Management

With the addition of the previous modules it is possible to automate the product costing function of the organization. Financial planning no longer needs to be performed using historical data as the basis. Labor requirements, inventory levels, material consumption, procurement expenditures and other relevant data can now be budgeted for in light of what is planned and expected to occur. Under MRP II the material costs and the labor costs of executing the production plan can be forecast in a much more accurate manner. The figures in the financial system under MRP accurately reflect what it costs to produce what is called for in the master schedule.

This accumulation of data under MRP II provides a wealth of information that can be used to make management more efficient and effective because it is action oriented rather than reactive.

III. SOFTWARE DESIGN CONSIDERATIONS

The degree of success MRP enjoys is a function of the organization's commitment to make it work. While MRP is installed in thousands of manufacturing firms across the nation, few are reaping the full rewards of their MRP system's potential. One study revealed that [Ref. 4: pp. 19-20],

> There is an incredible shortfall between actual results and potential. Of the 1480 firms included in the study, only 12% called themselves "winners".

Among those traits that these "winners" exhibited was that proper software design played a major role in the MRP development.

The major effort thus far at DMA Barstow has been to plan the MRP system by describing the data and files required, a rough sketch of how this data will be manipulated, and the type of reports or information output desired. The software with which to execute the system has not been written or purchased as of the date of this thesis. In order to evaluate software packages or to write the programs to accomplish what the DMA wants the system to do will require an understanding of the mechanics of how it is to be done by the system.

It is one thing to require the system to compute lead-times for requisitions, it is quite another problem to determine which method of calculation will be used. There are a myriad of algorithms and models to choose from; exponential smoothing, moving averages, simple averages, statistical projections and the use of filtering in each case. The problem is to determine which method will be used. A similar problem exists in determining order policies. Once

again, many methods exist for lot sizing but what model or combination of models should be employed at the DMA?

These specific questions must be considered before software selection is made or the programming begun. Almost certainly the software that is provided to the DMA's will be a standard software package that will require modification prior to installation. This package will contain desirable as well as some undesirable design aspects of which the DMA must be aware. If the package is to be modified successfully, the desired changes must be well thought out and documented to facilitate the reprogramming effort.

As a consequence of these considerations, a first step toward the DMA decision makers being informed customers is that they must understand the differences between a civilian manufacturing environment, for which most software packages are written, and the military depot level overhaul environment as it exists at DMA Barstow.

A. THE MASTER SCHEDULE

The master schedule environment in both areas under discussion is quite similar. The master schedule in the DMA is made up of forecasts of requirements which are subject to frequent changes and revisions. Priorities, due dates and quantities are changed frequently as the need arises. Both environments are characterized by mid-plan changes in order to meet changing demands as original forecasts are overcome by unexpected occurrences. The DMA workload is affected by new priorities to support field unit requirements just as the civilian manufacturer must respond to changing consumer demands. The depot overhaul program is less affected by these type of changes due its captive and limited set of customers and the budget cycle. However, when something major does occur, the flexibility must exist to adjust

rapidly and accommodate these new priorities and product requirements.

A recent example was the massive effort in preparation for the Near Term Prepositioned Ships (NTPS) program in 1980. A high volume of end items were processed through the DMA's on short notice to meet a new requirement of national concern. Another example would be the sudden surge in operations that would have to be accommodated in the event of war.

The major dissimilarity that exists in the master schedules is that the DMA has much more product diversification than is usual for a private sector company. An analysis of the DMA principal end item (PEI) workload in FY 83 and 84 is presented in table IV. As reflected in this table, the DMA services many different products. The quantities on each of

TABLE IV

Depot Level Maintenence Requirements (PEI's)

Product Group	No. of Jobs/No. of Items FY 83	FY 84
Communications/Electronics	18/566	30/423
Engineer Equipment	8/63	19/282
Motor Vehicle Equipment	15/1,409	27/1,006
Weapons	37/2,244	39/2,724
FY Total	78/4,382	115/4,435

the jobs worked, however, is small as is shown in table V. In addition to the small quantity worked on each job, The DMA PEI workload changes drastically from one fiscal year to the next. Only 47 jobs that will be worked in FY 83 will also be worked in FY 84. The remaining 68 jobs to be overhauled in FY 84 are new starts. An analysis of the other

TABLE V

DMA PEI Job Quantity Analysis

Quantity Range	Number of Jobs (Cummulative %) FY 83		FY 84	
1	10	(13%)	11	(10%)
2-4	25	(45%)	37	(42%)
5-10	9	(56%)	26	(64%)
11-20	11	(71%)	15	(77%)
21-50	11	(83%)	16	(91%)
51 +	12	(100%)	10	(100%)
Total	78		115	

major input to the DMA workload, secondary depot reparables (SDR's), is shown in table VI. This table shows the 4,386 SDR's that will be worked on 237 jobs in FY 83.

TABLE VI

FY 83 Secondary Depot Reparables Master Work Program

Quantity Range	Number of Jobs	Cummulative Percentage
1	26	11%
2-4	83	46%
5-10	55	69%
11-20	28	81%
21-50	26	92%
51 +	19	100%

B. THE BILL OF MATERIAL

End item configuration is typically controlled so that one M151A2C jeep looks much same as the next, only the paint may be different. Each end item is identified by a unique number called a National Stock Number (NSN), a thirteen

digit number used to catalog every item carried in the DoD supply system. This identification system provides one of the prerequisities discussed in Chapter II concerning the MRP system. An overhaul operation is inherently different from the standard manufacturing operation, overhaul could be referred to as a partial "re-manufacturing". When an item is overhauled, most of the component parts are processed as illustrated in Figure 3.1.

```
 ---------------    -------------   ------------------
| End Item      |-->+   Pass     | Y |     Cosmetic      |
| Disassembly   |   | Visual     +-->+     Process       |
 ---------------    |Inspection? |   | (sandblast,paint) |
                    -------------   --------+----------
                         |N                 v
                         v          --------+-------
                    -------------  N |    Pass      |
                   |  SALVAGE    +<--+ test/spec?   |
                    -------------    --------+-------
                         ^N                  v  Y
 -------------  Y    -----------      -------+-----
| End Item    +<----+   Pass     +<---+   Repair    |
| Assembly    |     |Test/Spec?  |    |   Process   |
 -------------       -----------       ------------
```

Figure 3.1 General Routing of a Part in Overhaul

At any one of the decision points in Figure 3.1 the item may be scrapped and a new part used to replace it. This requires that the BOM be modified to include an overhaul replacement factor which can be applied to adjust the gross parts requirements for the end item. Fundamentally, overhaul operations require two types of material, new and refurbished. Many of the refurbished materials are high dollar value components such as engines or hulls which are themselves made of new and refurbished parts. New part requirements are generated due to several factors;

1. Overhaul policy - the part is designated as mandatory replacement material.
2. Modification - current equipment replacement impelled by an engineering change.
3. Carcass absence - an otherwise refurbishable part is not returned with the end item for overhaul.
4. Inspection failure - either the item was not able to be refurbished or it failed to meet minimum specifications during the refurbishment process.

The first two factors are relatively easy to forecast and program into the BOM with an overhaul factor. The last two factors are more difficult to estimate yet cannot be overlooked without disasterous results. End items are received in various states of disrepair yet all these items are in condition code "F". Among these assets some are in better condition than are others. These are typically referred to as the "cherries" and their replacement demands for various parts may not be as high as those items in poorer condition. A program to maintain this factor would of course be required and should include the results of the pre-induction inspection.

The aspect of adding a replacement factor is a significant modification of the standard MRP logic (which assumes that every part on the BOM will be needed for sure).

C. SUPPLY SUPPORT

Because the DMA receives its supply support from three different pipelines (see Figure 2.1), the programming logic for the requisitioning process must be carefully planned. The first difference in this area is the different formats the requisitions must take in order to be processed. The Mini-BOM items, DoD system items, local procurement items, and Marine Corps BOM items are all requisitioned using

different forms, information, and communication media. Another difference is that private industry is able to establish long term contracts with suppliers who are paid according to a delivery schedule in order to ensure a continuous flow of materials required in the production process. The DMA relies on funded requisitions to external sources over whom little control can be exercised.

The Special Program Requirement (SPR) explained in Chapter II could be a very useful tool to ensure material availability at the IMM when needed by the DMA rebuild process. The MRP system will be able to forecast DMA material requirements over the planning horizon. There are limitations in the SPR program that must be recognized and addressed in order to ensure successful use of the system.

1. The SPR support date should not be less than 90 calander days nor more than 6 years from the date the SPR is received at the IMM.

2. The SPR support date must be at least one procurement leadtime away in order to insure acceptance at the IMM. If submitted within the procurement leadtime the IMM may be able to accept the SPR depending on the item's stock at the time the SPR is received.

3. The IMM uses certain acceptance criteria which must be known and used to determine which requirements are eligible for support under the SPR program.

It may be difficult for the DMA to forecast requirements given items with long ledtimes, the MRP planning horizon may not extend far enough in the future to identify these requirements. Therefore, items with leadtimes beyond the MRP plannning horizon will have to be identified using other means. Establishment of an MRP system that includes the use of SPR's would require further modification but the potential benefits to be gained are great. SPR's rejected by the

IMM would then become prime candidates for the DSSC Mini-BOM system and DMA requirements met by DSSC submitting requisitions for those materials instead of the DMA.

D. SAFETY LEVELS

Within the DMA there are two types of uncertainty in regards to material, demand quantity and supply timing. The former type was discussed in the previous section. Relative to supply timing, the DMA environment is punctuated by the seemingly unestimable availability of parts from the source of supply. A short leadtime for an item is frequently followed by an extended leadtime because the source subsequently runs out of stock while awaiting a replenishment procurement action.

A method for computing appropriate safety levels is required to ensure material availability during variable leadtime and uncertain demand quantities. These safety levels will vary depending on the characteristics of the job being worked. A relatively continuous rebuild line could afford to have safety levels established for it whereas it may not be economial to maintain safety stock to support a rebuild quantity of one which will not be repeated in following years. The MRP system should provide for these peculiarities in safety level computation and leadtime forecasting.

E. ORDERING POLICY

Lot-sizing techniques are plentiful in the inventory control community. There are a variety of continuous and periodic models from which to choose. The MRP environment is one of discrete period demands, therefore the popular EOQ model is not applicable. Joseph Orlicky writes [Ref. 3: pp. 137],

> There does not appear to be one "best" lot-sizing algorithm that could be selected for a given manufacturing environment, for a class of items, and in most cases even for a single specific item. For the purposes of MRP, the lot-for-lot approach should be used wherever possible and in cases of significant setup cost, least unit cost, least total cost, part-period balancing or even period order quantity should provide satisfactory results. When it comes to selecting a lot-sizing technique to be incorporated in an MRP system, one discrete lot-sizing algorithm is about as good as another.

The software proposed must be examined for the particular technique utilized in order to understand its processing logic. Lot-for-lot ordering minimizes the cost of holding inventory by only ordering a quantity equal to the net requirements for the period. The use of this technique would result in a high number of requisitions being submitted for high usage items. The ordering policy must also consider unit cost and if it were low then lot-for-lot may be overridden and another algorithm used such as fixed period.

Management at the DMA must decide what ordering policy is consistent with their inventory goals and objectives and incorporate them into the MRP system to be used. Manual reviews in the form of "firm planned orders" can be used to provide user controls over the system and should be considered. Another feature helpful in the rebuild environment is "requirement pegging". This allows the user to find where each part is used in the DMA. This is important during the screening of computer generated buys and this feature makes it easier to make engineering changes or part number changes to all BOM's concerned.

F. INTERFACES

The MRP system must interface with the DMSS as it is the accounting record from which all supply data is taken for job cost accounting and higher level reporting. Keeping the

DMSS database updated and in equilibrium with that in the MRP system will be an area of major concern to DMA management. This task will be a difficult one under the best of circumstances. Methods for maintaining both databases must be considered and included in the software package modification in tandum with the interface programs.

The MRP system will also have to interface with a variety of systems external to MRP; DMSS, the material returns program (the return of excess material for credit), the ESSEX time and attendance system, and the DoD supply system (requisition status, SPR's, etc). The method the MRP system uses to interface, whether manual or automatic, direct or through DMSS, will need to be decided prior to vendor selection to ensure the software product can be used.

IV. IMPLEMENTATION PLANNING

The implementation of computer based systems is a subject that appears in many professional periodicals with great frequency. Various authors report on their keys to successful implementaion or stress one particular aspect of implementaion strategy. The literature is filled with steps, phases, tests and stages that have been used to evaluate and prepare organizations for implementation of MRP. Consistent themes do emerge from all these various implementation strategies. The most agreed upon include:

1. Top level management support and committment is indispensible to MRP implementation.

2. User involvement throughout the system development and implementation phases are a prerequisite to overcoming user resistance.

3. Education of personnel at all levels in the organization before, during and after implementation is mandatory.

4. Preparation of the organization must be completed before implementation begins. This includes inventory, bill of material and routing accuracy and any organizational changes needed to accomodate the new system.

5. MRP requires discipline and the assignment of responsibility to specific members of the organization to ensure data integrity as well as processing correctness.

What quickly emerges from the literature is that implementation is a continuing process, it begins with system development and does not end until MRP has become fully absorbed into the organization.

The degree of acceptance of MRP appears to be a function of how much the organization depends upon the MRP system in its daily operations. Oliver Wight has classified MRP users into four catagories as shown in Table VII [Ref. 5: pp. 453-462]. As the table suggests, the implementation of MRP is not a guarantee of success. In order to receive the benefits of MRP, an organization does not have to become a class "A" user. Many class "B" and "C" users are realizing many benefits from MRP without the total commitment of a class "A" user. Any organization should strive to become a

TABLE VII

Categories of MRP Users

Class of User	Dependence on MRP
A	* MRP is used to run the business, it is the game plan used by all components of the organization. * MRP plans so well that no shortage list is needed.
B	* MRP isn't directly used to run the business. * MRP is seen as a production and inventory control system. * The shortage list really tells them what to do.
C	* MRP is used as an inventory ordering technique. * Shop scheduling is done from the shortage list. * The master schedule is typically overstated. * Benefits are limited to inventory reduction.
D	* MRP only works in the data processing department. * Inventory records are poor. * Mismanaged master schedule.

class "A" user but this is an evolutionary process and the path to class "A" must be carefully considered, aggressively pursued and once attained, stringently managed.

Implementation can be viewed as consisting of four stages; education, preparation, conversion, and evaluation. Some stages exist concurrent with others and are themselves made of various phases.

A. EDUCATION

The psychological impact of a new system has been found to be highly significant in that system's eventual success or failure. To lessen the impact it will have, involvement and education of the organization's personnel at all levels is required. Education should begin early in the MRP system development when the system is first being visualized. It begins with the involvement of the users in the development of the MRP system. What is MRP? How does it work? How will I be affected? Does this mean my job will be abolished? Many of these apprehensions can be avoided if an effective education program is developed. Oliver Wight writes [Ref. 5: pp. 465],

> No one who has ever installed an MRP system successfully ever said, "We did too much education!". No one who has done it unsuccessfully failed to say, "We didn't do enough education!".

Education should be tailored to the specific audience with the appropriate amount of time and detail spent according to their level of involvement with the system. The education should be a phased approach; don't cover too much of the subject at one time. Become progressively more targeted in the subject matter as the education stage progresses. It is during this stage that commitment from the top levels of management is obtained and filtered downward so that everyone in the organization is drawn to the MRP bandwagon.

Who should be educated in the organization? The answer is a resounding "everyone"! MRP is a people dependent system, it requires that everyone within the organization participate and communicate in its terms to make it work. People at all levels will be reading its reports, inputing data, or be dependent on its process. Everyone should be instructed in what their role will be in the system, educated as to how to do it and then told how their part fits in the whole system. As the system development process continues and the particular aspects of the MRP system are finalized, training can begin on the inputing of data and the use of the reports that will be output once the system is operating. A good rule to follow is to start educating as soon as you have something to educate about [Ref. 5: pp. 140-142]. Follow-on education after implementation must be developed to keep personal skills finely honed to preserve system integrity and keep personnel involved with the system. New employees will also have to be educated on MRP and integrated into the system.

There are a variety of sources for MRP education available on the market today. Many universities offer MRP executive training sessions. There are also many private companies that offer MRP training which is highly regarded. Software and hardware vendors also sponsor workshops and seminars that seek to educate with varying degrees of product promotion interwoven in the MRP pitch. Video courses on MRP are also available from several sources. The American Production and Inventory Control Society (APICS) frequently sponsor seminars and workshops on MRP and can provide information on other sources available for MRP education. Education should be approached with the idea that the most critical element in MRP is people, they must not only know what they are doing but why they are doing it.

B. PREPARATION

The first thing one must realize is that MRP requires a lot of hard work. There is no such thing as a "turn-key" system. Don't expect to leave on a Friday and return to work on Monday finding a new MRP system in place and ready for operation. The organization must prepare itself for MRP in a number of areas before implementation begins, education is but one. Several other prerequisites of MRP were enumerated in Chapter II. The first three mandatory elements for MRP were; a master schedule, a bill of material, and current inventory records. These elements must be up-to-date and accurate. Inventory accuracy must stand at 95% or better and the bill of material accuracy must be 98% or better [Ref. 6: pp. 78].

The education process can serve as a motivator for key personnel in these areas to purge existing files and make sure resident data is accurate prior to system implementation. It is also during this preparation stage that any organizational, physical or policy changes to ensure data integrity must be made.

1. Organizational Changes

Responsibility for data accuracy must be established, the responsible individual given the assets and authority to maintain that accuracy, and his performance measured in some manner. Those responsible should be held accountable and supported in their efforts to maintain accuracy [Ref. 7: pp. 34]. The master schedule must be prepared by representatives from production control, inventory control and shop management. It should be reviewed periodically and procedures established concerning changes and updates. The schedule must be a realistic projection of what the company can do, not what it would like to do [Ref. 6: pp. 79].

2. Physical Changes

Because the requirement for inventory accuracy is so essential to a successful MRP system, the inventory has to be secured and access limited. For most companies this is the most prevalent physical change required. Inventories may have to be relocated to a more secure area or made more secure in their present location. No item can enter or leave the inventory unless it is accompanied by an appropriate transaction report to the MRP system. Changes may also have to be made in the manner in which the material is stored to facilitate the periodic inventory checks required to maintain that accuracy.

3. Policy Changes

Decisions regarding order quantities, safety levels and leadtimes must be made prior to implementation. Some of these policy decisions will have to be made during the systems design process and were discussed in chapter III. Their inclusion here is required to ensure that these policies are in fact known throughout the organization and included in the software package. The most significant policy change for the organization may be the decision to abide by the strict discipline required by MRP. The determination of the organization to support and utilize the system must permeate every level if every member is to be convinced to follow the established procedures.

4. Implementation Team Leader

Preparation cannot begin without the selection of an implementation project leader who will oversee the organization's implementation effort. Most literature reviewed concluded that the best project leader is one who has a stake in the outcome and therefore, a vested interest that

MRP be successful. This person is one who knows the organization, its products and people, and especially its problems. Oliver Wight lists four of the most common mistakes made in choosing a project leader [Ref. 5: pp. 367-369].

1. Using a systems person. Systems people are an indispensible part of the project team but the leader must be a user.

2. Using an "outsider" as the project leader. It is easier to teach a person who knows the organization about MRP than vice versa. This does not mean that an outsider can't be part of the team.

3. Picking a "boy to do a man's job". The leader should have enough credibility to convince experienced personnel that they are going to change their behavior and conform to the disciplines of MRP.

4. Trying to use a part time project leader. When a project leader isn't full time, MRP installation tends to drag on while the leader repeatedly returns to his regular job to solve other crises.

The project leader is the change agent for the organization and as such is the representative of the Chief Executive Officer. He develops the implementation plan, monitors its progress and ensures it proceeds by mediation, conciliation, and edict, if necessary.

C. CONVERSION

There are four methods that can be used when converting to a computer-based system [Ref. 8: pp. 147-150].

1. The "Cold Turkey" Method

The conversion in this method is abrupt, users are forced to "sink or swim". This requires that the system be well planned and promoted or disaster is sure to strike.

This method may be applicable in some situations where the people involved need to be forced to make it work. The main disadvantage of this method is the culture shock it produces among users.

2. <u>The "Parallel" Method</u>

In this approach the new system is operated side-by-side with the current system. The main disadvantage to this method is that the conversion time can be lengthy because people tend to cling to the old system rather than make the break and go with the new system.

3. <u>The "Phase-In/Phase-Out" Method</u>

This method allows the old system to gradually expire while the new system is brought on-line. This method can be very effective but established milestones need to be enforced in order to ensure transition to the new system.

4. <u>The "Pilot" Method</u>

This method allows only a small portion of the organization's functions to be affected. It provides an opportunity to evaluate the new system in actual operation and localize its effects. Any faults can be easily identified and corrected before any further implementation takes place. It also affords an opportunity to observe the system's effects on personnel and determine if further education is required. If all goes well the participants can become the best sellers of MRP in the organization.

D. EVALUATION

Implementation is not over when "the switch is flipped" and the system is turned on. A method to measure the effectiveness of the system must be established and its

performance reviewed to determine if further action is required. Procedures must be audited periodically to ensure that the system is being utilized and maintained properly. If procedures are not being followed, an investigation is needed into the reason for not doing so. System changes may have to be made or it may be a matter of conducting more training.

Keen and Morton offer eight methodologies of evaluation to be matched to the specific situation of the organization [Ref. 9: pp. 215-224].

1. Decision Outputs

This evaluation technique determines if the system produces "better" decisions that the ones made prior to implementation. In the case of the DMA, an example might be to compare repair part inventory levels experienced after the implementation of MRP with those levels before MRP. This would be an indicator that MRP may be helping to reduce inventory investment. Other key indicators can be used in this manner to better evaluate the system and its effectiveness. However, this technique should not be used as the sole evaluator and should be complimented by other evaluation measures.

2. Changes in the Decision Process

This technique evaluates changes in the way decisions are made, irrespective of the decision output. To determine whether the system is actually being utilized, the descriptive models of how the personnel perform their jobs before and after system installation can be compared. This should show if different information and analysis is now used in the decision process and how close it comes to the optimal normative model used by MRP. Are informal systems

still in existence and to what extent are they used? Another technique is to use "traces" to determine who is using the system and what information is being sought. This tells the evaluator which parts of the system are being utilized, in what manner, and how frequently.

3. Changes in Concepts of the Decision Situation

During the development of the DMA system, various managers had an opportunity to indicate what information they felt was needed in order to improve their decision making capabilities. This process in itself provided great insight into worker frustration. The impact of the system on the manager's cognitive processes is the most relevant in this method of evaluation. It is the manager's subjective judgement of the system and its impact on their jobs that is important. Do they explore more alternatives with the system? Are new insights or knowledge gained through the new system used in their decision making? Is more information now readily available to them in a form which is useful? The answers to these questions will give the evaluator an idea of the system's usefulness to the users.

4. Procedural Changes

MRP requires strict adherence to the procedures for attaining data accuracy. Previous procedures that allowed inaccurate data to be tolerated must not be allowed to reappear.

5. Cost/Benefit Analysis

Some costs of the new system are easy to assess; hardware, software, or additional personnel required to run the system. Other aspects of the system will be more difficult to quantify. Benefits such as improved communication,

ease of production tracking, or generation of better reports are typically hard to translate into definite figures. Costs such as the psychological cost of change, time and commitment of managers, and disruption caused by the new system are equally hard to quantify. However, the cost/benefit analysis of the system is not complete without the inclusion of these "hidden" costs and benefits. This method of analysis is important but should be used in conjunction with the other methods of evaluation.

6. Service Measures

Poor service can quickly undermine a system's credibility and value to the organization. The evaluation process is not complete without including some measure of the quality of the system from the perspective of the user such as; system responsiveness, reliability, availability and convenience of access and the quality of system support.

7. Manager's Assessment of the System's Value

One way of finding out the system's value is to ask the managers. This should be done periodically and can be an indicator of user resistance or a warning sign of design flaws. It is also interesting to contrast the results obtained by this method with the other methods. Contrasting conclusions should be explored and the basis revealed so that corrective action can be taken.

8. Anecdotal Evidence

This method is used to collect perceptions and feelings and look for significant details in an informal manner. By just being a good listener the evaluator can gain insights, examples, opinions and events that help to supplement the formal evaluation process.

The key questions that should preceed and determine the selection of evaluation techniques are proposed by Keen and Morton [Ref. 9: pp. 225].

1. What is the organization trying to accomplish?
2. What are the criteria for determining success or failure?
3. How will the organization know when the system is complete?
4. How can the organization determine if the effort was worth the cost?

V. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

A. SUMMARY

DMA Barstow has completed the initial efforts of designing the DMA Integrated Management System (DIMS) and CMC is about to begin procurement of the hardware and software required. The system design uses MRP as the basis for material requirements planning and scheduling workload through the DMA. The standard logic used in MRP will require some modification before it can be applied to the overhaul environment experienced in a military depot rebuild facility. Some unique factors include:

1. Because not every part in a component is always replaced in the rebuild process, the bill of material must be modified to include a "depot replacement factor" which is the probability that a given part will be replaced.

2. Safety levels will play a significant role in the planning due to the uncertainty of demand quantity and the leadtime variability experienced from external supply sources.

3. The DMA processes a wide range of products, most of which will need to have a BOM file prepared.

The DMA must now begin planning for a successful implementation of the proposed system. The involvement of DMA personnel thus far has been limited to members of the design team who have consulted with a few functional personnel for brief periods. Formal training and education has been limited to those personnel on the design team. An implementation plan has not yet been developed but work must begin soon to prepare the DMA personnel for assisting in the software selection and the installation of an MRP system in the activity.

B. CONCLUSIONS

1. The DMA must begin a vigorous campaign of education to prepare its personnel for the installation of DIMS.

2. Inventory accuracy is not sufficient to accomplish a successful implementation of an MRP system.

3. The bill of materials must be formalized and controlled in order to attain the level of accuracy required by MRP.

4. Routing must be formalized and the data developed for loading to the MRP system.

5. An implementation plan must be developed in order to control all the activities that will be taking place prior to installation of the MRP system.

C. RECOMMENDATIONS

1. Education

A series of mandatory classes on MRP must be established that are tailored toward the degree of exposure the audience will have to the MRP system. The personnel clerk is not vital to MRP but the goal must be to educate everyone so that they will know at least what MRP is and how it can help the DMA perform better.

a. Key Personnel

Key personnel are those who supervise those personnel that will have the most contact with the system. In the case of the DMA this would include the following personnel;

a. Implementation Project Leader

b. Implementation Team Members

c. Head, Material Control Section

d. Head, Planning Section

e. Head, Material Expediting Unit

f. Head, Shops Control Section

g. Head, Systems, Procedures and Analysis Sect.

h. Head, Production Planning and Control Branch

i. Head, Methods and Standards Section

These are the personnel in the DMA who will be expected to get the DMA prepared for MRP, to assist in the conversion, and to keep the system operating once it is installed. Therefore, it is only prudent to give them the proper education to perform the task. It is recommended that they attend a live off-site class given by an experienced professional in the MRP field. There are many "consultants" giving classes on MRP but their credentials should be carefully checked. It is recommended that on-site classes be avoided for these personnel for the following reasons [Ref. 5: pp. 387-391].

a. Interaction with people from other organizations allows them to discuss their problems and find that theirs are not unique.

b. A different attitude towards learning exists in the classroom as opposed to the conference room.

c. On-site education can quickly degenerate into discussions about specific problems and education falls by the wayside.

For the above reasons it is recommended that the DMA send the key personnel identified above to an off-site MRP education class. Many 5-day classes are offered by such recognized experts in the field as Oliver Wight, George Plossl, Joseph Orlicky, Robert Garwood and others. Additional education is available through APICS and they can be contacted to find class schedules.

b. Top Management

The Director, Deputy Director and Head, Shops Branch should also attend off-site education classes in MRP. Their particular class should not be on the details of MRP as the key personnel will receive, but of sufficient depth that they will be conversant on the subject. This class will also impress upon them the need for their support during the preparation, conversion and evaluation stages of the implementation. Typical courses for top level managers are 2 to 3 days in length and can be found from the same sources as that for the key personnel.

c. The Critical Mass

The most effective technique to educate the remaining DMA personnel is through the use of video courses and on-site classes given by supervisory personnel who have attended the 5-day course. A number of the video courses are available by lease or purchase. These should be screened for content prior to use. These courses can be tailored to the audience by varying the depth and length of the course matter.

Everyone in the organization should be required to attend some class on MRP before the implementation. Most people on the peripheral of the MRP system need only an introduction on the subject. The foremen on the shop floor at all levels need to be instructed but are frequently left out of the education process which can have adverse effects later.

d. Training vs Education

Training is the detailed education that will come when the software has been selected and modificaton begun. Those who will have "hands on" the new system need

to be shown how to enter, extract and process the data they will be handling. It is a good idea to get the terminals onboard as soon as possible to assist in this training.

e. Continuing Education

The education process must not end with the installation of the MRP system. Course outlines and training aids used in the initial classes should be retained to train new personnel coming into the system. Refresher courses on various subjects must be prepared and a schedule of retraining made to maintain skills. An active education process must be pursued once MRP comes on-line in order to maintain the commitment of DMA personnel.

2. Preparation

a. Select the Implementation Leader

The first thing to accomplish in the implementation phase is to select the individual who will be the project leader. It is this individual who will guide the course of the implementation of the system. His team should be made up of a representative from the following areas of the DMA; financial management, production control, systems, material control, industrial engineering, quality control and shops branch. These people should have a great degree of knowledge about their areas if they are to provide input to the team leader concerning their field. In addition, they should be held responsible for their area's preparation for the implementation.

In order to effectively control these activities, the project leader should be someone from within the organization who has the credibility and existing authority to enable him to get the job done. If any vendor representatives are obtained due to the procurement contract, they should work with him.

b. Inventory Accuracy

A 95% accuracy is a high but not impossible goal to attain. It does require commitment from the highest levels of management to the newest worker in the organization. Oliver Wight cites banks as an example of a business that routinely attains 99.99% inventory accuracy. [Ref. 5: pp. 211].

During the analysis phase of this thesis, the DMA inventory was judged to be 70% accurate. This was based on a review of several cyclic inventories that had recently been conducted. A further investigation of those inaccurate records was made and one third of them were found to be system related (a receipt or issue recently made had not yet posted to the inventory record). If given credit for these late postings, the DMA inventory accuracy is still only 80%. This is far from the 95% needed to make MRP successful. Clearly, the DMA must improve this aspect of operations significantly before implementation can take place. It is recommended that the following steps be taken to improve DMA inventory accuracy.

1. Establish the objective. The goal of 95% accuracy must be set at the highest levels in the DMA, it should come from the Director's office.

2. Assign line accountability. The accountability for inventory accuracy should flow down from the Director to the head of PP&C Branch to the head of Material Control to the warehouse foreman. All in the chain should know that they are accountable for ensuring that inventory transactions are handled properly so that inventory records are correct as a consequence.

3. Create understanding. Everyone concerned with the inventory; warehouse workers, supply clerks and their supervisors and the workers on the shop floor must

understand why this objective is vital to the MRP system. This should be stressed at the education classes so all will know and help support the effort

4. Provide the tools to do the job. The DMA already has limited access stores so the concept of physical security is not new. However, it is recommended that some organizational changes within the Material Control Section be made. As the section is now organized, the warehouse unit consists soley of warehouse workers, the foreman, and one GS-3 supply clerk who maintains the warehouse locator file. The warehouse personnel do not make any entries to the DMSS file that records on hand balances. This is all done by three GS-4 supply clerks in the Supply Operations Unit located one-half mile away in the main DMA building. In order to consolidate the responsibility for inventory accuracy, it is recommended that the three GS-4 supply clerks be relocated to the warehouse and placed under the supervision of the warehouse unit foreman. As these clerks prepare all receipts, issues and inventory adjustments at present, the only change in their work assignment would be their location and supervisor. In this manner the accountability for inventory is centralized in one area, the warehouse, and the warehouse foreman has all the assets he needs to control the inventory under his direct supervision.

5. Measure performance. Cycle counting is a method for obtaining a measure of inventory accuracy. The goal of 95% should be incorporated with the merit objectives of the warehouse foreman and his measurement should be the result of the cyclic inventory. A fair tolerance level must be established in concert with the cycle count and a reasonable time table to accomplish 95% accuracy developed. A reasonable goal would be to have 90% accuracy in four months and 95% accuracy at the end of six months. This accuracy

will not be achieved by a physical inventory alone. It must be followed with sound and practical procedures that are adhered to by workers and enforced by management.

The important thing to remember is that MRP cannot be implemented before inventory accuracy is 95%. There is still time available before the system is purchased and this process must start now so that the implementation will not be needlessly delayed.

c. Bill of Material Accuracy

The DMA does not have a formal bill of material established for the items it processes. However, there are sufficient manuals for each end item that will assist in the preparation of the product structure required in the BOM. This process will require an allocation of many personnel resources for an extended period in order to create the structured bill of materials for each item in the schedule.

1. It is recommended that structured BOM's be prepared using a team consisting of; one supply technician, an engineering technician, and a representative from the applicable cost work center (CWC) for each component of the end item. There should be a minimum of three such teams who are engaged full time in this effort. The supply technician will be needed to provide the usage history that may be available, research part numbers for NSN's, verify NSN's, and identify possible substitutes. The engineering technician will verify component and end item configuration, establish the routing plan, approve substitute items (subject to QC approval) and with the CWC representative, establish initial depot replacement factors for the refurbished materials. The CWC representative will provide the technical expertise in product repair that is essential to determining initial depot replacement factors, the routing

plan, and to highlight items which he knows to have long or variable leadtimes.

2. The team should be provided a permanent work space separate from their normal work areas yet situated close to the technical library where the publications are maintained.

3. The CWC representative should change as the team works through the end item product structure and it should be arranged so that he spends the minimum amount of time off the shop floor.

4. As each structured BOM is completed, each participant should review the work and sign off on the BOM.

5. There should be an appeal process established that will have the final determination in the event there is disagreement among the team as to structure, route plan or replacement factors. This appeal should be heard by the parent CWC foreman, a QC inspector and a member of the implementation team.

6. Each team's progress should be monitored by the implementation team leader and reviewed weekly with the team members and higher management.

7. Disk file space should be provided by ASC to store the structured BOM when completed. This will facilitate the loading to the MRP system, ease filing problems and allow for review when required. The SCANDATA device should be used as the input medium and ASC should be requested to develop an entry screen menu and provide hard copy output of the completed BOM file upon request.

8. Once established, it is recommended that the BOM file be secured so that only the Industrial Engineering personnel who are responsible for its maintenance and accuracy are allowed to make changes.

The creation of the BOM file is seen to be the most critical and time consuming portion of the DMA preparation. The effort should be focused initially on those 78 PEI's and 237 SDR's to be worked in FY 83. Once these are accomplished, attention should turn towards the FY 84 workload and work begun on those items that are new starts. The mechanism for future BOM creation already exists in the form of a Repair Division Order [Ref. 10]. Contained in this document are the actions required in the pre-production phase of major items. It is recommended that this document be changed to eliminate the development of a Supply Support Plan and require the creation of a structured bill of material in its stead using the team approach where necessary.

d. Routing Accuracy

Routing accuracy must also be at 95% or better prior to installation of MRP. The DMA presently has no formal system for routing control and this must be developed in connection with the BOM creation. The routing file can then be created for each item by the BOM team and loaded to a separate disk file which has the same advantages as those previously identified for the BOM.

3. Conversion

a. Pilot Selection

It is recommended that conversion be accomplished by use of a pilot study. This method has significant advantages over the other approaches discussed earlier in this thesis. The pilot will allow a test of the modified MRP system under real-life operations. Its adequacy can be observed and any changes needed identified and dealt with quickly. The pilot will also test the people using the data and determine if more training is required.

What product line or CWC should be used as the pilot? It is recommended that the small arms shop, CWC 721, be selected and all product lines worked by that CWC be included in the pilot project. The small arms shop is a microcosm of the DMA environment. It has a varied product mix; .45 caliber pistols, machine guns and howitzers. These weapons use both new and refurbished parts and they have a well known routing plan. The BOM's are easy to build and replacement factors should be easy to quantify. In addition, the small arms shop is largely self-contained and the effects of the pilot will be localized. This will permit the remainder of the DMA to continue normal operations and provide a relatively stable environment to evaluate the effectiveness of the MRP system.

b. Implementation Schedule

In his book on MRP II [Ref. 5], Oliver Wight presents a strong argument for an 18-month implementation schedule. Darryl Landvater also recommends the 18 month approach [Ref. 6]. However, neither of these schedules considered the need for the determination of the probabilistic replacement factors which are necessary to the DMA environment. It will take some time to estimate the initial values and may extend the schedule beyond 18 months.

It is recommended that the DMA utilize a phased time schedule over a period of 24 to 30 months to ensure a methodical and systematic conversion to MRP. It is recommended that the conversion be made by grouping like products together and converting all at the same time. This approach would be very similar to the "phase-in/phase-out" approach during this stage of the conversion. This would permit the completion of work in process under the old system but new work coming in would be worked on the new system. For those

jobs that are continuous (M60 tank, etc) the phase-in could start with a particular increment. Using this method, all work in the DMA could be converted over a period of six to eight months.

4. Evaluation

The MRP system should be evaluated during and after its implementation. Objectives must therefore be established as a basis for this evaluation. They should include all eight methodologies discussed in chapter IV. In particular, the following factors should be part of the list of objectives.

1. Has the system resulted in the average 10%-20% reduction in on hand inventory which is typical of a good system?
2. Has the system reduced the amount of material ordered but not used?
3. Has the number of material shortages decreased?
4. Are people using the system to explore alternatives before making decisions?
5. Are informal systems still in existence and to what degree?
6. Do the users feel confident in using the system? Are they able to interact with the system?

The service measures discussed in Chapter IV are another good indicator of system effectiveness and it should be verified that the system is meeting them as called for in the system specifications. Periodic reviews with the first level supervisors should be held by the implementation project leader to highlight any user problems that may develop and corrective action explored.

5. Computation of Overhaul Replacement Factors

Initial estimates of replacement probabilities cannot be based on historical usage since that data is not kept at the present time. It is recommended that the initial factors be estimated by using the expertise of the personnel in the CWC that will be performing the overhaul and engineering estimates.

When historical data becomes available, it is recommended that the probability of the replacement of a repair part in a given end item be calculated using the procedure developed by Professor McMasters of the Naval Postgraduate School which is included in appendix A.

Professor McMasters utilizes the computed probability of replacement in the development of a single period inventory model that is used to determine the depth of repair parts stocked to support NARF overhaul activities [Ref. 11]. This model assumes that the random demand can be modeled by either the binomial or normal probability distributions. McMasters is presently involved in an effort to extend this single period model into a multi-period model for NARF Alameda. When completed, the mulit-period model could have application at DMA Barstow and should be evaluated for use in the determination of the depth criteria for stock to meet the DMA rebuild requirements. Additionally, NARF Alameda has recently let a contract to obtain the software necessary to compute replacement probabilities for repair parts and create BOM's for items rebuilt in that facility. This software could be adapted for use at DMA Barstow or used as a guide in the preparation of it's own program to compute these probabilities.

6. <u>Ordering Policy</u>

It is recommended that the ordering policy adopted by DMA Barstow be sensitive to unit price and usage. For those items with a low unit price but high usage, a fixed-period technique to determine order quantity is recommended. For those items with a high unit price and moderate to low usage, the lot-for-lot technique is recommended. Further study to determine the economic breakpoints for each technique is required and recommended.

7. <u>Special Program Requirements</u>

It is recommended that the DMA include the use of SPR's in the DMA Integrated Management System. MRP forecasts material requirements in discrete time periods for all materials needed to meet the master schedule. However, not all requirements will be candidates for submission of an SPR. Some things to consider in deciding which requirements should be submitted are listed below.

a. SPR's should be limited to material required not less than 90 calander days after nor more than 6 years after the submission of the SPR.

b. The acquisition advice code is important to the SPR decision process because it identifys that material which is managed by the IMM but not stocked and therefore not eligible for the SPR program. Since an SPR for this material will be rejected by the IMM, this data element should be included on the inventory file and examined before attempting to establish an SPR.

c. The quantity identified on the SPR should be no less than a month's requirements. Anything less than this (ie; weekly) is rolled to the first day of the month by the DLA SPR program [Ref. 12].

The major advantages in the use of SPR's is when unacceptable variability in an item's leadtime is experienced, the item is critical to the rebuild process, or when the end item to be rebuilt is a new start. However, once the SPR is accepted by the IMM the subsequent requisition for the material must contain a demand code of "P". In the past, a demand code of "R" has been ocassionally used by DLA customers and the demand is filled from regular stock rather than the reserved stock. The system should provide some method of identifying the SPR requirements to ensure that requisitions are prepared in advance of the support date and coded properly.

For those situations where the procurement leadtime is not known the MILSTRAP Logistics Asset Support Estimate (LASE) system can be used [Ref. 1: Chapter 13]. Using this system, an inquiry is submitted to the IMM through DAAS for a given NSN. The IMM will respond with the procurement leadtime on its file and include other pertinent data concerning the NSN such as, acquisition advice code, unit of issue, on hand peacetime assets, other war reserve material requirements protected, net due-in, and the quarterly forecasted demand. LASE can also provide a breakdown of all IMM backorders in priorities 1-8 and 9-15 by service. Much of this information would be useful in determining eligible items for the SPR program.

8. Safety Levels

At this time an adequate probabilistic model to compute safety stock in the discrete demand environment of the DMA has not yet been developed. Safety levels should then be determined using a heuristic approach. The DMA can use safety stock as protection against the following two circumstances, requisition leadtime variability and repair part replacement rate variability.

Usage Per Year	Purchase Order Leadtime (in days) 0-59	60-119	120
Low (less than 1)	no	yes	if critical
Medium (1-3 items)	if high leadtime variability	if critical or high leadtime variability	yes
High (more than 4)	yes	yes	yes

Figure 5.1 Safety Stock Matrix

A safety stock matrix similar to the type used by the Long Beach Naval Shipyard, as shown in Figure 5.1, is worth considering for protection during requisition leadtime [Ref. 13]. A similar approach is recommended for the determination of safety stock for the case of replacement rate uncertainty.

APPENDIX A

COMPUTATION OF REPAIR PART REPLACEMENT PROBABILITIES

The probability of the replacement of a repair part in a given item can be calculated using the following formula:

$$\hat{p} = \frac{\sum_{j=1}^{m} x_j}{\sum_{j=1}^{m} n_j}$$

where x_j is the total number of demands in quarter j and k is the units of application per n_j and items overhauled in quarter j.

The formula above provides the best estimate of replacement probability since it gives the smallest confidence interval for a given level of significance due to larger sample size. An additional advantage in using the largest sample is that the impact of carry-overs from one quarter to the next can be minimized in the event that a requisition is placed for more than just immediate needs.

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